Chapter 6.6
Underwater operations safety and health

This could be you . . .

A scuba diver was working upside-down for about 45 minutes when he noted a slight chest pain. The diver was treated for medistanal emphysema and returned to diving after 2 weeks.

During a free-dive training exercise, a dive instructor suffered from shallow water blackout. A dive student retrieved the instructor from the pool bottom. Surface observers performed cardiopulmonary resuscitation on the dive instructor.

1. Applicability of this chapter

You are required to follow this chapter if you operate or work with neutral buoyancy facilities, plan open water training, or use other non-open-water facilities.

2. What this chapter covers

This chapter covers dive operation for open and non-open-water diving. It includes the following:

a. Underwater testing and training

b. Dive standards

c. Requirements for divers, equipment, and breathing gases

d. General operating procedures

3. Open and non-open-water diving

For the purpose of this chapter, non-open-water diving is conducted in water that is in a manmade enclosure and is treated with chemicals.

Non-open water diving

4. Steps to follow when using a neutral buoyancy facility

As a test requester or operator, you shall:

a. Follow Chapter 6.9, "Space systems and test safety," of this handbook for training and testing operations in JSC neutral buoyancy facility (NBFs).

b. Follow the requirements in NASA-STD-8719.10, "Standard for Underwater Facility and Non-Open Water Operations."

c. Develop a dive plan that includes the following at a minimum:
   1. Purpose of the test.
   2. Test objectives.
   3. Scope of the test.
   4. Test requirements.
   5. Safety and medical planning provisions.
   6. Any known medical issues.
   7. Any special precautions or safety considerations.
   8. Method of testing.
   9. Other items that might be required by the NBF you are using.
   10. The NBF's critical lift procedures.

The NBF may have more requirements than those listed here.

Open water diving

5. Requirements for open water operations

If you, as a test requester, are involved with human open-water testing or training, you make your management, the Safety and Test Operations Division, and the Clinic Services Branch aware of your intentions.

6. Standards for open water operations

You shall:

a. Follow 29 CFR 1910, Subpart T, "Commercial Diving Operations."

b. Develop alternate standards if your operations involve unique equipment and methods not addressed by OSHA. These standards shall be:
   1. Developed by the responsible line management.
   2. Based on consensus standards.
   3. Approved as described in Chapter 1.4, "Written Safety and Health Program," of this handbook.

Other requirements that apply to open and non-open water diving

7. Using the "buddy system"

As a diver, you shall use the "buddy system." Never dive alone unless all of the following are true:

a. There is an emergency and someone's life is in danger.

b. You volunteer for the rescue. No one may force you.

c. You are in direct visual contact or are tethered.

8. Medical requirements for dive team members during a test

You shall have a medical examination:

a. At least yearly by a doctor who knows the hyperbaric conditions that you will encounter, your mode of diving, and what type of work you will be doing. If you are a guest diver, you shall have an examination at least every 3 years.

b. Before diving.

c. If you are injured or become ill and have to be hospitalized for more than 24 hours.

d. At the attending doctor's discretion.

9. Training for dive team members

You need to be certified as described in Chapter 5.8, "Hazardous operations: safe practices and certification," of this handbook. Your formal training shall include the following:

a. The use of the tools, equipment, and systems that you will use.

b. Techniques and procedures of the assigned diving modes, including the buddy system concept and open water communication.

c. Diving operations, including diving-related physics and physiology.

d. Emergency procedures, including cardiopulmonary resuscitation and first aid for lifeguards only.

10. Minimum requirements for breathing gases and diving equipment

Breathing gases and equipment used in NBFs shall meet these minimum requirements of Chapter 6.13, "Safety and Health Requirements for Ground-Based Breathing Gases and Breathing Gas Systems," of this handbook. Document and correct all discrepancies that you find in the equipment before you use it on any more dives.

11. Electrical equipment for underwater use

You shall follow these requirements for electrical equipment used underwater:

a. Tools and underwater equipment shall meet the minimum electrical requirements contained in this section of NASA-STD-8719.10, or be accepted for use by an ad hoc committee composed of representatives of the Center's safety, underwater facility line management, medical, and electrical engineer with bio-electrical experience. The special ad hoc committee:

   1. Shall assess the shock hazard, recommend controls to reduce or eliminate the hazard, and discuss the risk associated with any remaining hazards.

   2. Shall present its results to the appropriate Test Readiness Review Board (TRRB) for approval.

b. You are responsible for safeguard batteries used underwater to prevent hydrogen outgassing, and packaging them to prevent chemical leakage into the water or electric short circuits from water leaks.

c. You shall protect personnel from exposure to any electrical hazard that can result in injury, created by underwater tools and equipment, by at least two independent verifiable controls. Controls need to be verified operational before use. The potential for exposure to electric currents greater than or equal to 6.0 milliamperes represents a potential electric hazard.

d. The special ad hoc committee mentioned in subparagraph 11.a above shall review tools, equipment, or systems using greater than 30 volts (alternating current (AC) (root mean square), direct current (DC), or combination) and present the results to the TRRB for approval before use in the underwater facility. Tools and underwater equipment limited to 30 volts or less (AC (rms), DC, or combination thereof) that include a verifiable barrier to electric shock are not normally considered potentially hazardous.

e. You shall install listed ground fault circuit interrupters in the branch circuit supplying underwater lighting fixtures operating at more than 15 volts AC so that there is no shock hazard during re-lamping.

f. Areas around the pool that are subject to saturation with water or other liquids shall be considered "wet area locations" and protected with listed ground fault circuit interrupters in the branch circuits.

12. General operating procedures

If you oversee any diving operations, you need to have a "safe practices manual" available to each dive team member at the open water dive location. The manual shall include standards, general information, requirements, and:

a. Specific procedures and checklists for each diving operation. See paragraph 14 below for minimum requirements.

b. Responsibilities of the dive team members and support personnel.

c. Equipment procedures and checklists.

d. General emergency procedures, including rescue techniques and medical treatment.

13. What the general operating procedures need to cover for each dive phase

Follow these requirements:

a. The pre-dive phase shall include:

1. Planning the dive.
2. Assessing the safety of the dive.
3. Identifying and inspecting equipment and supplies.

b. The dive phase shall include:

1. Entering and exiting the water.
2. Communications between divers and surface personnel.
3. Dive profiles and limits.
4. Individual and crew responsibilities.
5. Decompression tables as appropriate.
6. Tools and equipment.
7. Use of hazardous materials.
8. Dive termination under normal and emergency conditions.
9. Use of support and rescue equipment.

c. The post-dive phase shall include:

1. Checks on physical conditions of the divers.
2. Other precautions necessary following the dive.
3. Preparation of records of the dive.
4. Records of equipment malfunctions.
5. If required, assessment of recompression capability and decompression procedure.

14. Pre-dive briefing

Before the dive you need to have a diver and crew briefing by a person familiar with the safety requirements and operational aspects of the dive. The briefing shall include a review of the following:

a. The applicable portions of the safe practices manual.

b. The specific operating procedures and individual diver and responsibilities.

c. Dive profiles and operational limits.

d. The buddy system (no one dives alone), assignments of pairs, and communications.

e. Emergency and rescue procedures and responsible personnel.

15. Records

You shall keep the following records, make copies available for employees to review, and protect them under the Privacy Act of 1974:

a. Records, reports, and other documents pertinent to the safety and health of employees in open water operations. You shall prepare and maintain them under an established schedule that includes at least the requirements in OSHA 29 CFR 1910.440, "Record Keeping Requirements."

b. Breathing air records, such as sampling and analysis results.

c. Records of all maintenance on the diving equipment and support apparatus.

d. Records of all materials used in an oxygen-enriched environment if enriched gas mixtures are used.

16. Responsibilities for underwater safety

The following have responsibilities for underwater safety:

a. If you are a ***line manager***, you are responsible for making sure that the regulations in this handbook and applicable OSHA regulations are met.

b. The ***Safety and Test Operations Division*** is responsible for:

1. Making sure that human testing, training, or preparations follow the regulations in this handbook, applicable OSHA regulations, and approved procedures.

2. Monitoring all suited subject testing or training. The Safety and Test Operations Division may decide to monitor other testing or training.

c. The ***Medical Operations Branch*** is responsible for:

1. Monitoring all human testing or training based on the requirements of NASA-STD-8719.10.

2. Making sure that the people involved in open water operations meet the physical requirements to perform their duties.